What is claimed is:

1. A method of forming a copper diffusion barrier on top surface of a low-k interlayer dielectric layer in a semiconductor device, the method comprising:

forming at least two copper interconnect structures within the low-k interlayer dielectric layer;

treating the top surface of the low-k interlayer dielectric layer to transform a thin surface layer of the low-k interlayer dielectric layer into a copper diffusion barrier.

2. The method according to claim 1, wherein the step of treating the top surface of the low-k interlayer dielectric layer includes plasma surface treatment in which the top surface of the low-k interlayer dielectric layer is bombarded by nitrogen atoms from the plasma formed from at least one nitrogen-containing gas, wherein the copper diffusion barrier is a layer of silicon nitride.

3. The method according to claim 2, wherein the at least one nitrogen-containing gas is nitrogen gas.

4. The method according to claim 2, wherein the at least one nitrogen-containing gas is ammonia gas.

5. The method according to claim 2, wherein the layer of silicon nitride is less than 100 angstroms thick.

6. The method according to claim 2, wherein the layer of silicon nitride is less than 50 angstroms thick.

7. The method according to claim 1, wherein the step of treating the top surface of the low-k interlayer dielectric layer includes plasma surface treatment in which the top surface of the low-k

interlayer dielectric layer is bombarded by carbon atoms from the plasma formed from at least one carbon-containing gas, wherein the copper diffusion barrier is a layer of silicon carbide.

8. The method according to claim 7, wherein the at least one carbon-containing gas is carbon-dioxide.

9. The method according to claim 7, wherein the layer of silicon carbide is less than 100 angstroms thick.

10. The method according to claim 7, wherein the layer of silicon carbide is less than 50 angstroms thick.

11. The method according to claim 1, wherein the step of treating the top surface of the low-k interlayer dielectric layer includes ion implantation using at least one nitrogen-containing gas, wherein the copper diffusion barrier is a layer of silicon nitride.

12. The method according to claim 11, wherein the at least one nitrogen-containing gas is nitrogen gas.

13. The method according to claim 11, wherein the at least one nitrogen-containing gas is ammonia gas.

14. The method according to claim 11, wherein the layer of silicon nitride is less than 100 angstroms thick.

15. The method according to claim 11, wherein the layer of silicon nitride is less than 50 angstroms thick.

16. The method according to claim 1, wherein the step of treating the top surface of the low-k interlayer dielectric layer includes ion implantation using at least one carbon-containing gas, wherein the copper diffusion barrier is a layer of silicon carbide.

17. The method according to claim 16, wherein the at least one carbon-containing gas is carbon-dioxide.

18. The method according to claim 16, wherein the layer of silicon carbide is less than 100 angstroms thick.

19. The method according to claim 16, wherein the layer of silicon carbide is less than 50 angstroms thick.

20. The method according to claim 1, wherein the low-k interlayer dielectric layer is of a silicon based organic-inorganic hybrid material.

21. The method according to claim 20, wherein the silicon based organic-inorganic hybrid material is one of hydrogen silsesquioxane and methyl silsesquioxane;

22. The method according to claim 1, wherein the copper interconnection structure is a dual damascene structure.

23. The method according to claim 1, wherein the copper interconnection structure is a single damascene structure.

24. The method according to claim 1, wherein the low-k interlayer dielectric layer is of a polymeric dielectric.

25. The method according to claim 24, wherein the step of treating the top surface of the low-k interlayer dielectric layer includes depositing a thin layer of material containing silicon and nitrogen by vaporization; and curing the deposited silicon and nitrogen containing layer to form the copper diffusion barrier of silicon nitride.

26. The method according to claim 24, wherein the step of treating the top surface of the low-k interlayer dielectric layer includes applying at least one chemical that contains silicon and

nitrogen; and facilitating silicon and nitrogen to form a thin layer of silicon nitride on the surface of the low-k interlayer dielectric through chemical reaction.

27. The method according to claim 26, wherein the step of facilitating silicon and nitrogen to form a thin layer of silicon nitride includes elevating the temperature of the copper damascene structure to about 50 to 100 deg. Celsius.

28. The method according to claim 24, wherein the step of treating the exposed surface of the low-k interlayer dielectric layer includes depositing a thin layer of material containing silicon and carbon by vaporization; and curing the deposited silicon and carbon containing layer to form the copper diffusion barrier of silicon carbide.

29. The method according to claim 24, wherein the step of treating the top surface of the low-k interlayer dielectric layer includes applying at least one chemical that contains silicon and carbon; and facilitating silicon and carbon to form a thin layer of silicon carbide on the surface of the low-k interlayer dielectric through chemical reaction.

30. The method according to claim 29, wherein the step of facilitating silicon and carbon to form a thin layer of silicon carbide includes elevating the temperature of the copper damascene structure to about 50 to 100 deg. Celsius.

31. A copper damascene structure in a semiconductor device comprising:

a low-k interlayer dielectric layer having a top surface;

at least two copper interconnect structures within the low-k interlayer dielectric layer;

a thin layer of copper diffusion barrier formed on the top surface of the low-k interlayer dielectric between the at least two copper interconnect structures to prevent copper diffusion between the copper interconnect structures along the top surface of the low-k interlayer dielectric layer.

32. The copper damascene structure of claim 31, wherein the copper diffusion barrier is a thin layer of silicon nitride.

33. The copper damascene structure of claim 32, wherein the thin layer of silicon nitride is less than 100 angstroms thick.

34. The copper damascene structure of claim 32, wherein the thin layer of silicon nitride is less than 50 angstroms thick.

35. The copper damascene structure of claim 31, wherein the copper diffusion barrier is a thin layer of silicon carbide.

36. The copper damascene structure of claim 35, wherein the thin layer of silicon carbide is less than 50 angstroms thick.

37. The copper damascene structure of claim 31, wherein the copper interconnect structure is a dual damascene structure.

38. The copper damascene structure of claim 31, wherein the copper interconnect structure is a single damascene structure.